The Case for Renewable Energy

EES 3310/5310

Global Climate Change

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Class #34: Monday, April 12 2021

The Big Picture:

Two perspectives on worldwide decarbonization: 50% below 1990 by 2050

Pielke

- Cutting emissions to 10,800 MMT by 2050 would mean building
  - 4.4 nuclear power plants per week for 40 years
  - Or 1000 solar plants per week
  - Or 4000 wind turbines per week
- This sounds impossible

Alternate

- Meeting growing energy demand with fossil fuels would mean building
  - 3 coal-fired plants per week
  - Or 3 nuclear plants per week
- If demand for coal grows at almost 2% per year, what happens to price?

Conclusion: Providing energy will be a big challenge whether we use clean energy or fossil fuels.

Jacobson & Delucchi (2009):

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End-Use Power (Trillion Watts)

	2010	2030
US	2.5	2.8
World	12.5	16.9

Note: 1 TW = 90 quads/year

- **Goal:**
  - All *new* energy from Wind, Water, Sun by 2030
    - US: 0.3 TW
    - World: 4.5 TW
  - *All energy* from WWS by 2050
  - Cost: $100 trillion over 40 years
    (vs. $10 trillion for fossil)

Efficiency from Reliability

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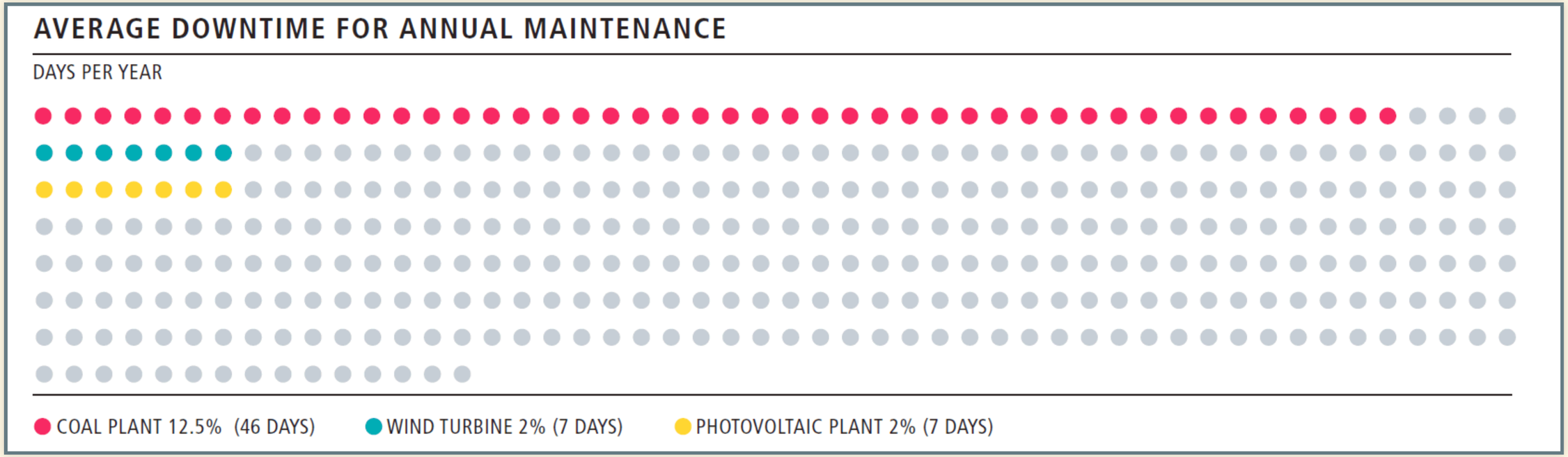


Energy Requirements in 2030:

- 16.9 TW conventional energy
- 11.5 TW with efficiency/reliability gains
- Gasoline car is 17–20% efficient
- Electric car is 75–86% efficient

Energy Sources

Energy Sources

Recommended

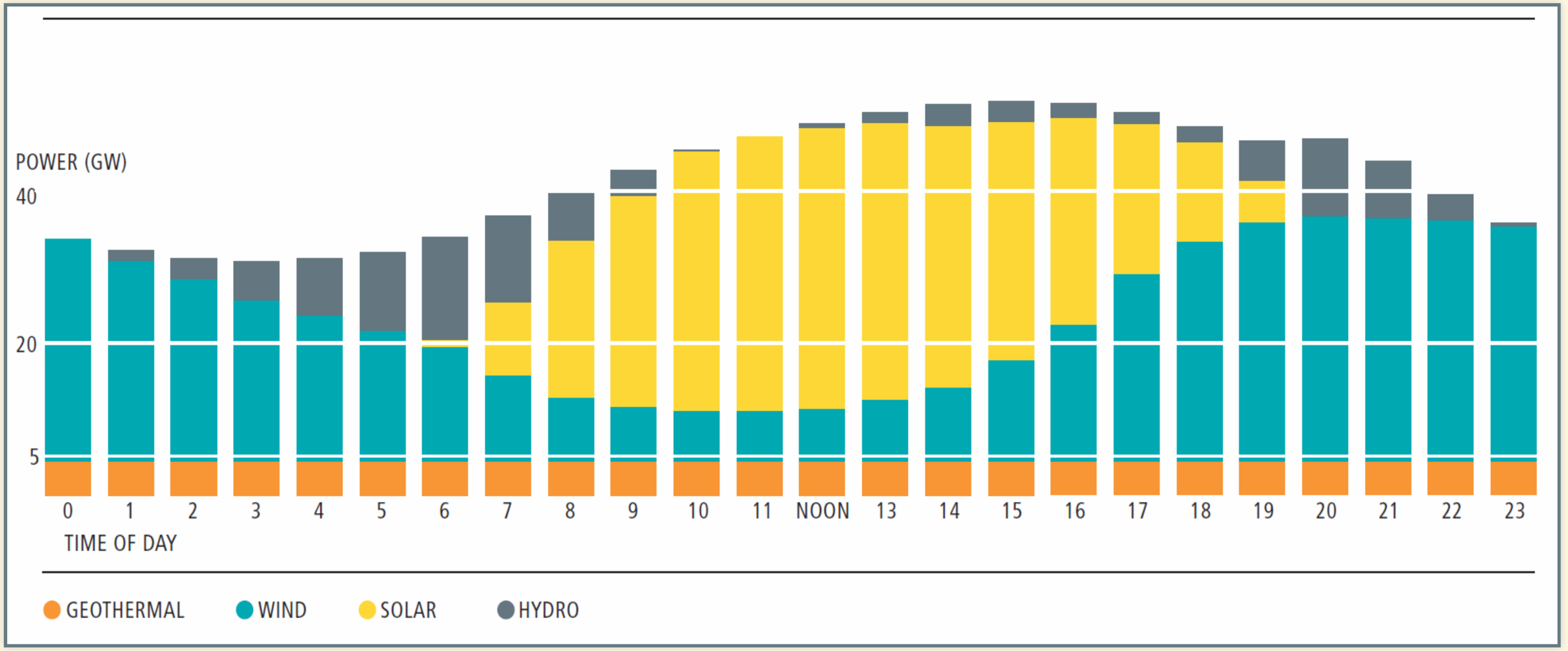
- **Generation**
  1. Wind
  2. Concentrated Solar
  3. Geothermal
  4. Tidal
  5. Solar Photovoltaic
  6. Wave
  7. Hydroelectric
- **Storage**
  1. WWS with battery-electric
  2. WWS with hydrogen fuel cell

Not recommended

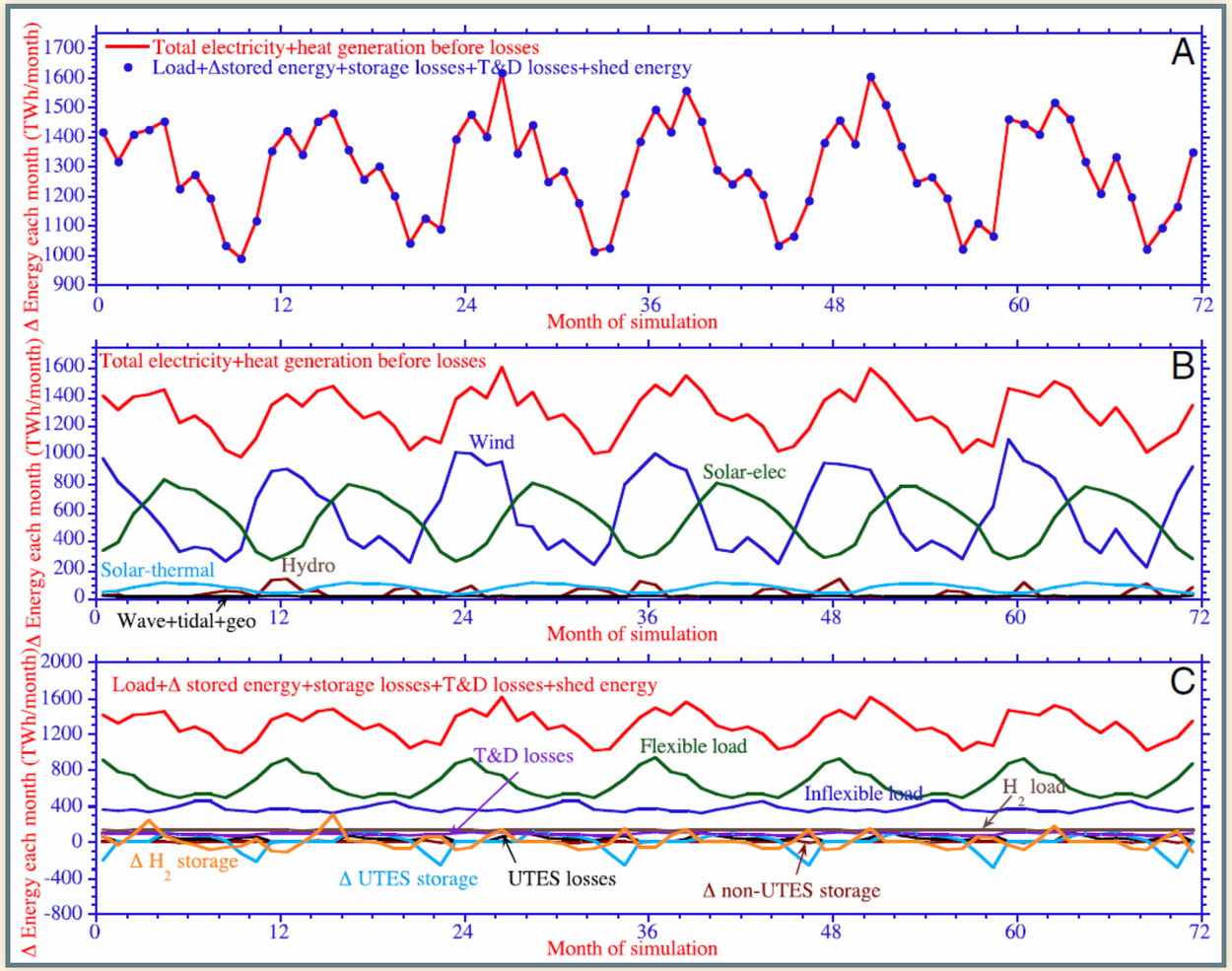
- Coal with carbon-capture and storage
- Nuclear
- Biofuels

Supply variability

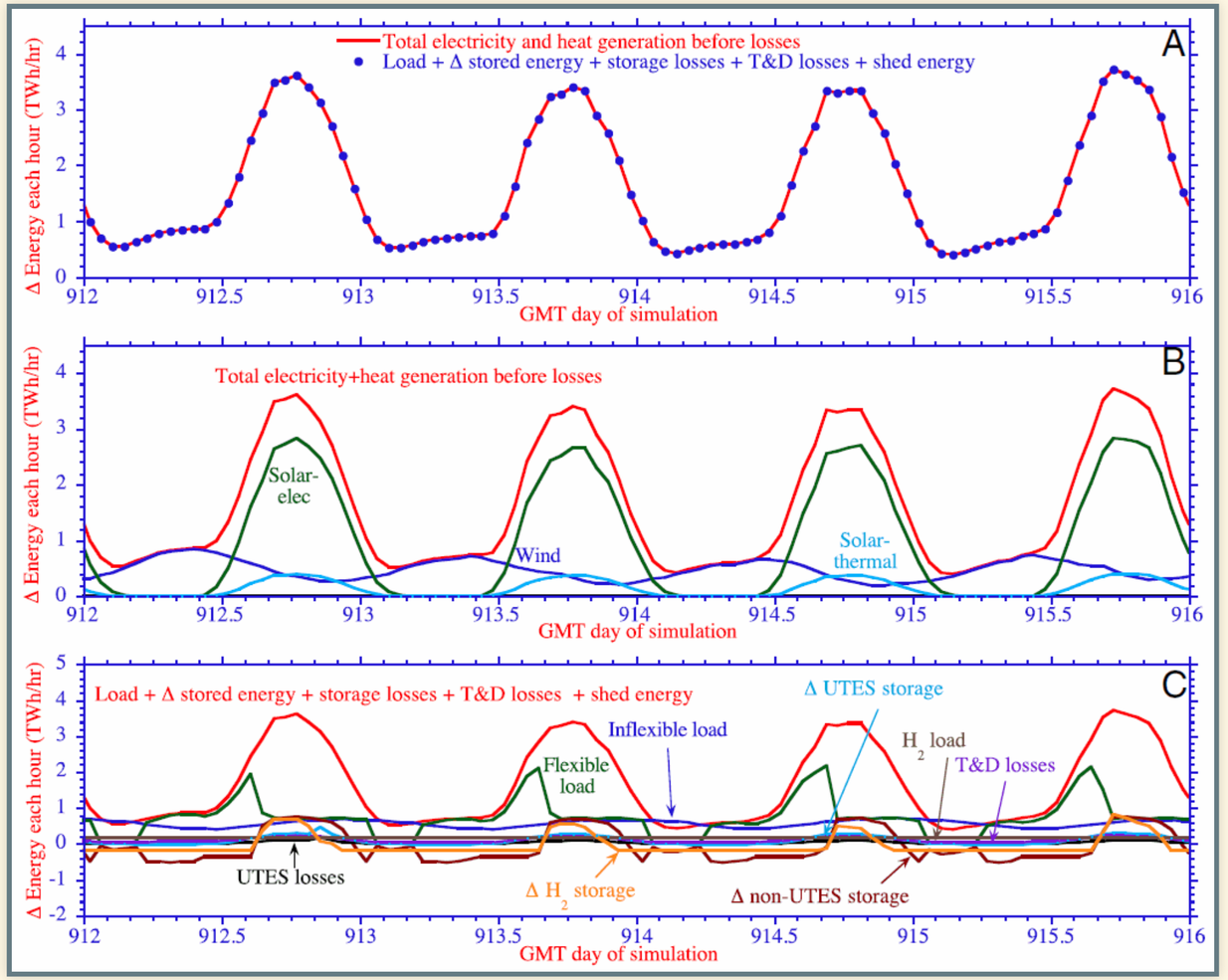
Balancing variable sources



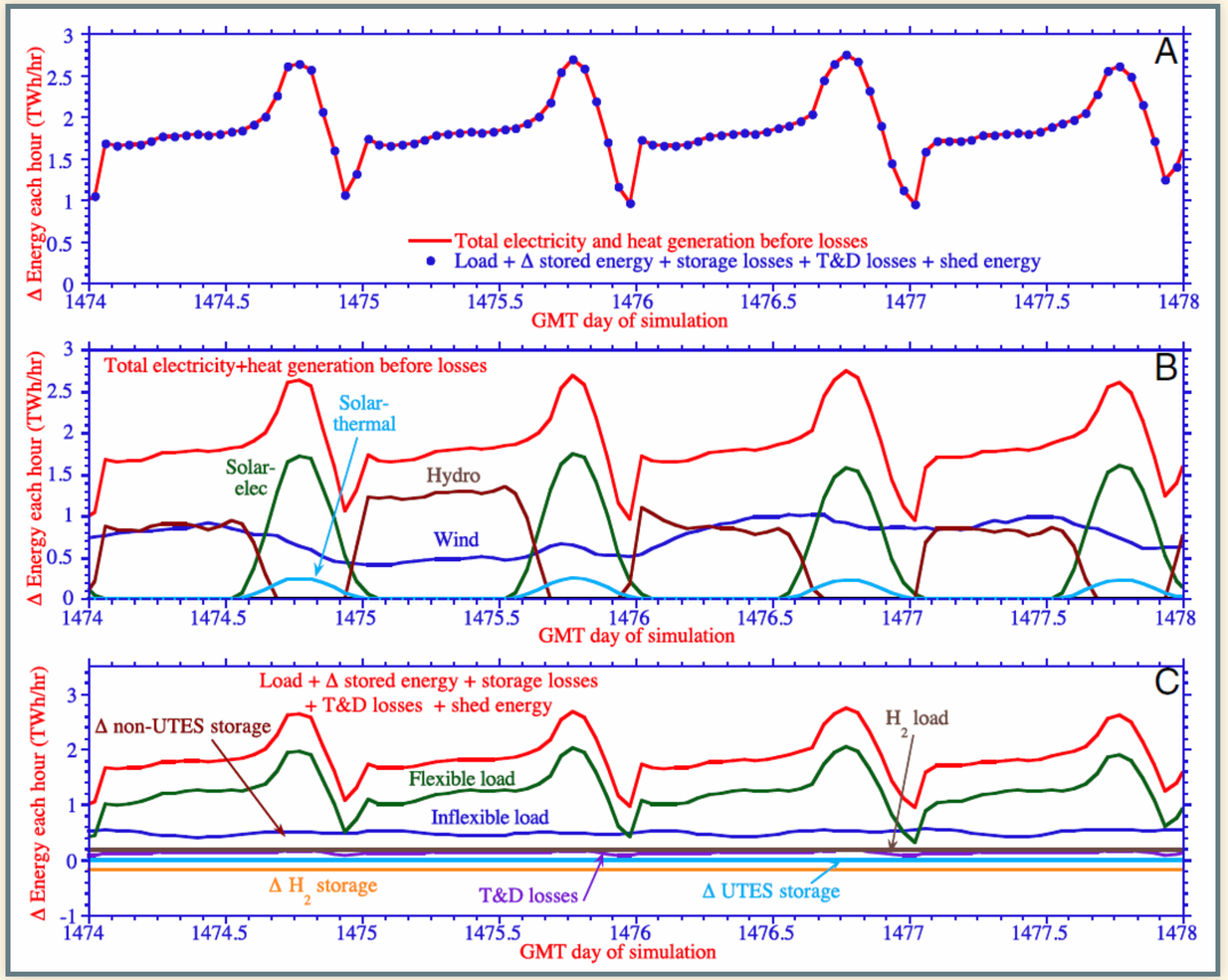
Seasonal Variations



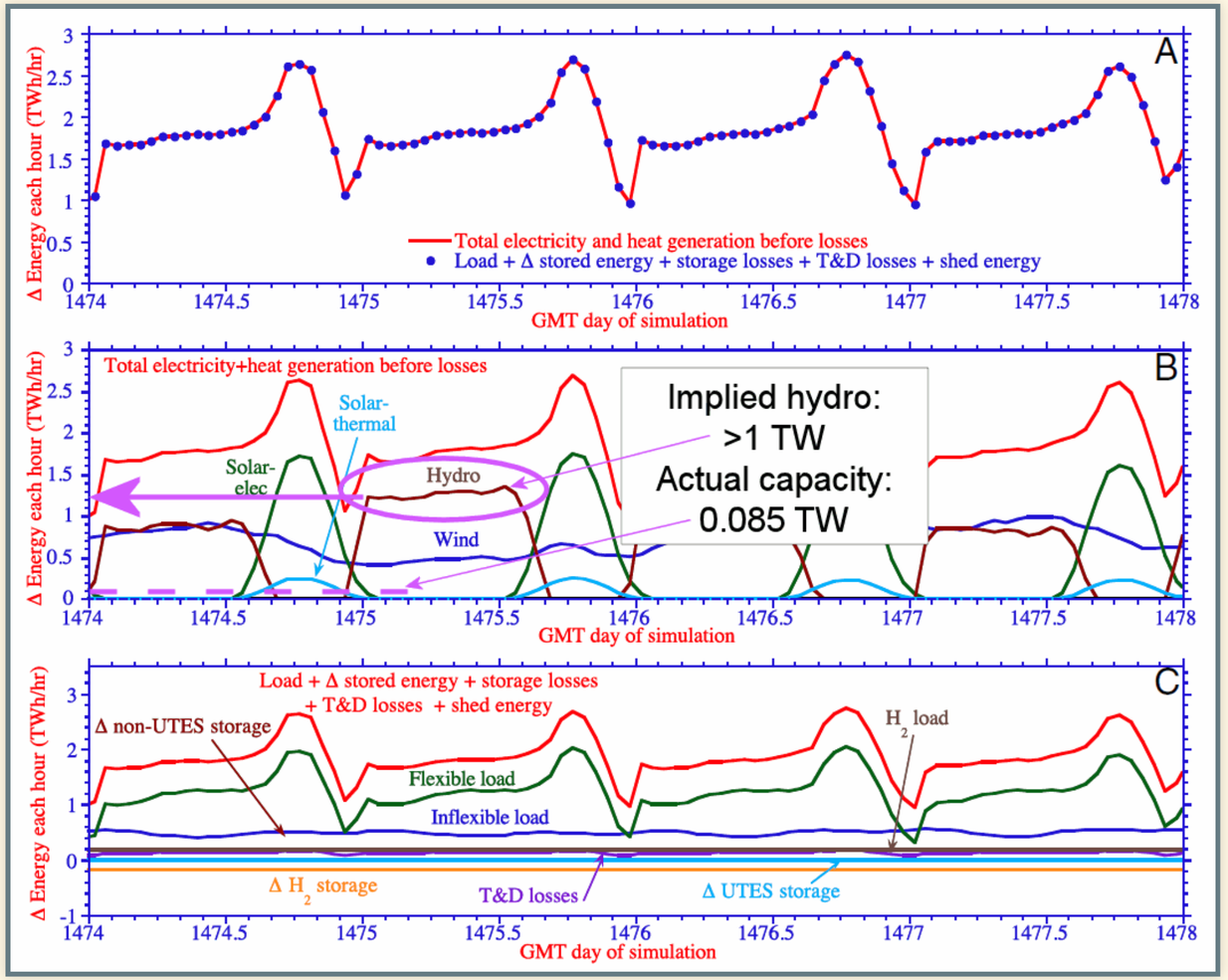
Daily Variations (July)



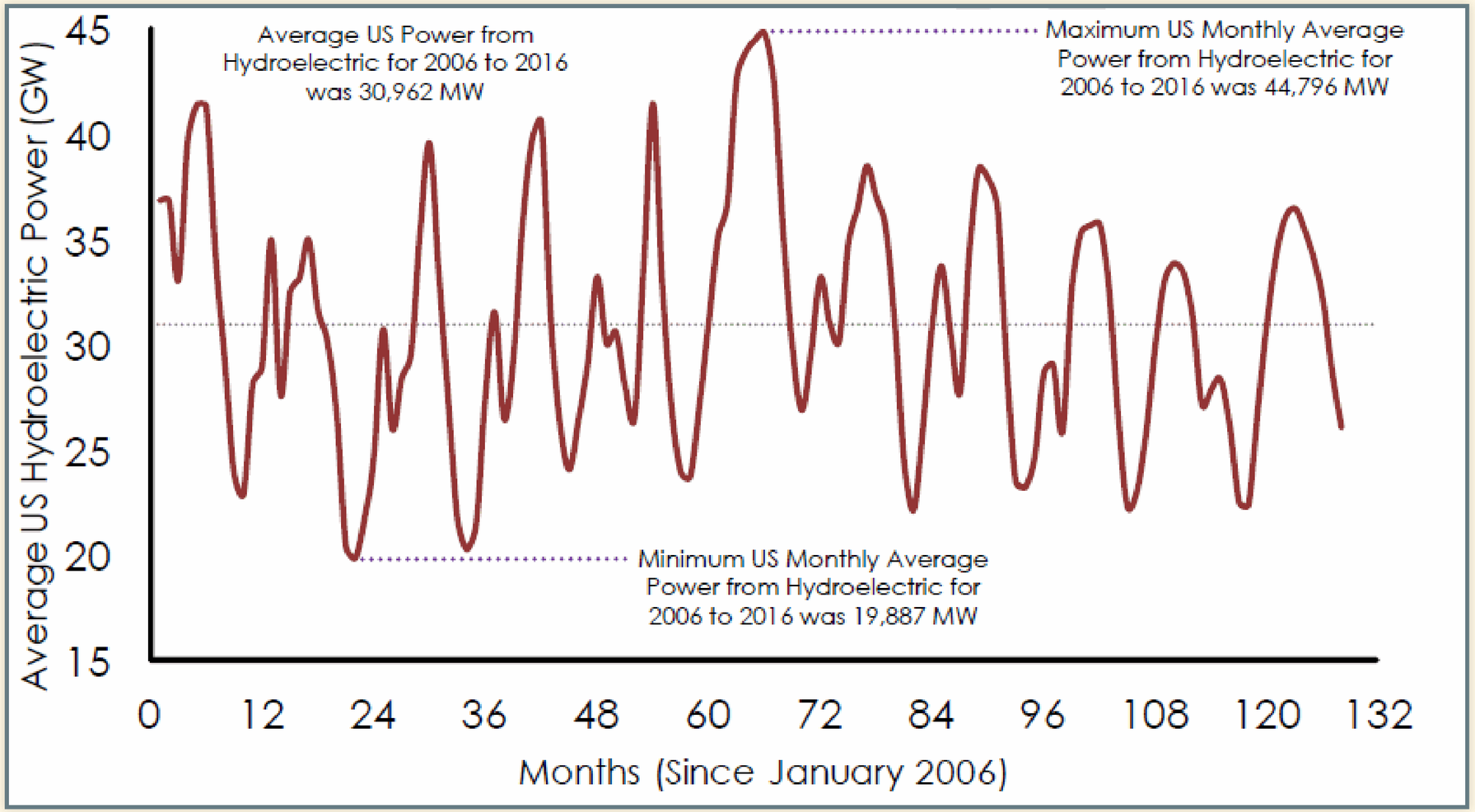
Daily Variations (January)



Plausibility of Hydroelectic Assumptions



Actual Hydroelectric Output (2006–2016)



Hydroelectricity

- Jacobson claims 1,300 GW peak hydroelectrricity
- Today’s capacity is ~88 GW
- Jacobson assumes 1500% increase in generating capacity for existing dams:
  - Install 15 times more turbines in existing dams
  - Peak water discharge from many dams >5 × greatest historical floods:
    - Flooding
    - Disruption of ecosystems (fish, etc.)
    - Disruption of agricultural/irrigation use
- New turbines, retrofitting dams not included in cost estimates

Energy Storage: Underground Thermal

- Assumes massive increase in underground thermal energy storage (UTES)
- Massive infrastructure (pipes, pumping)
- Possible, but very expensive, not included in cost estimates
  - Could add $1.8 trillion

Hydrogen

- Jacobson assumes 100,000 times more hydrogen production than today’s world capacity.
- Assumes hydrogen-powered airplanes by 2035

Modeling Climate and Energy

- Jacobson’s analysis rests on models written by Jacobson’s team
  - Many other climate models are open source, available to other scientists
  - Jacobson’s are closed source
  - Other models participate in Coupled Model Intercomparison Project to compare accuracy, identify strengths & weaknesses
  - Jacobson’s models have not participated
- Novel electrical supply/demand matching model LOADMATCH has not been made public or tested independently.

Big Picture

Big picture

- Big disagreement about small differences.
  - Jacobson’s critics believe it’s practical to get 74–84% of electricity from clean energy sources:
    - 58–68% from renewables
    - 16% from nuclear
    - 16–26% from natural gas
  - Jacobson insists 100% wind, water, solar, and believes nuclear is a very bad idea
- Even if Jacobson is correct, his cost estimate is $100 trillion over 20–40 years ($2.5–5 trillion per year: 3.2–6.5% of global GDP).
  - Is there political will to spend this much?
  - Jacobson claims renewable energy will repay investment in fuel savings

Subsequent Developments

Jacobson Sues Critics, Journal

- **Sept 2017:** Jacobson filed a $10 million defamation lawsuit against his critics and the journal Proceedings of the National Academy of Sciences for publishing their criticisms of his work.
  - Claimed critics and journal “knowingly and intentionally published false statements of fact.”
  - Insisted his critics were corrupt and were in the pay of the fossil fuel and nuclear power industries.
- **Feb 2018:** Jacobson dropped the lawsuit